Advanced Controls Research

FY2005 DOE Wind Program R&D Implementation Meeting

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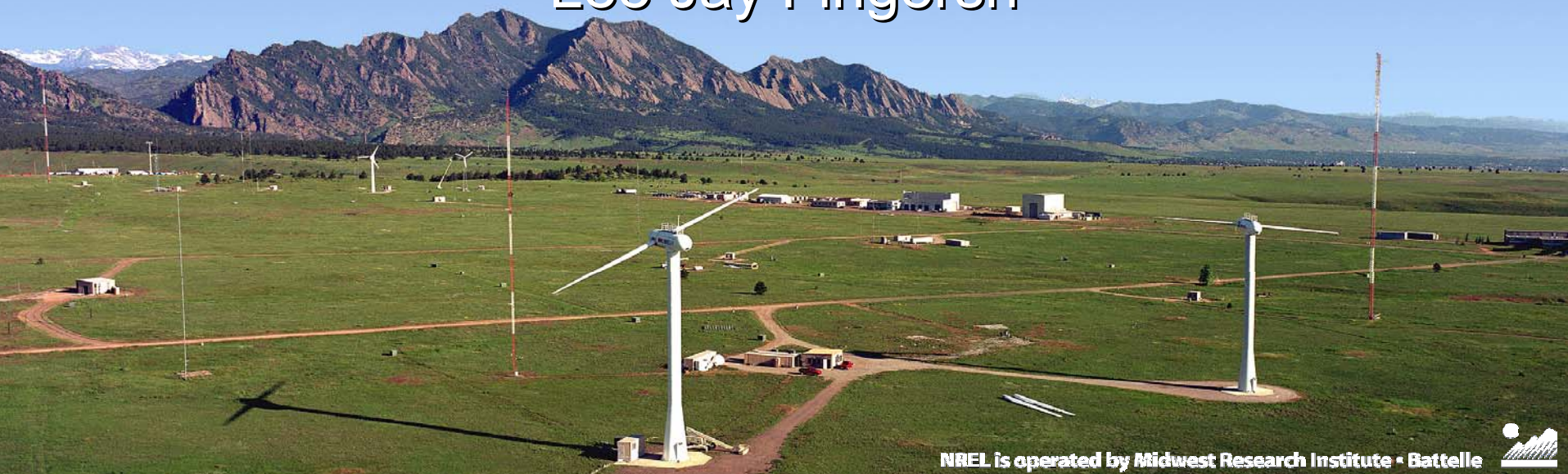


Past turbine controls

- Constant-speed
- Stall-controlled
- Controls
  - Startup/shutdown contactor or soft-start
  - Yaw or unwind
  - Brakes

Controls on current turbines

- Variable-speed
- Pitch controlled
- Controls
  - Generator torque ($T=k\omega^2$)
  - Collective pitch control (PID)
  - Yaw
  - Brakes
  - Possibly frequency filtering

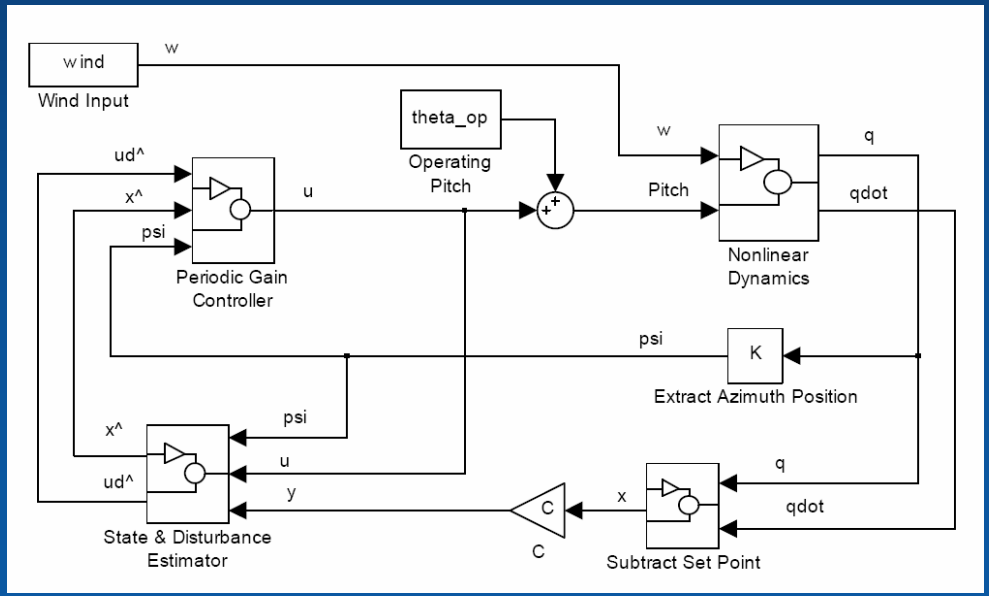
What else can we do?

- **Improve energy capture**
  - Active rather than passive rotor control
    - Negative inertia - Use of shaft torque to cancel rotor inertia
  - Adaptive control
  - Active pitch following
  - Optimal torque control
- **Reduce loads**
  - Load feedback
  - Independent pitch control
  - Periodic gains
  - Active tower / blade / drive-train damping
  - Advanced sensors
  - Look-ahead controls

The process

Design
Linear Model
DAC
LQR

Simulate
FAST
ADAMS
Simulink

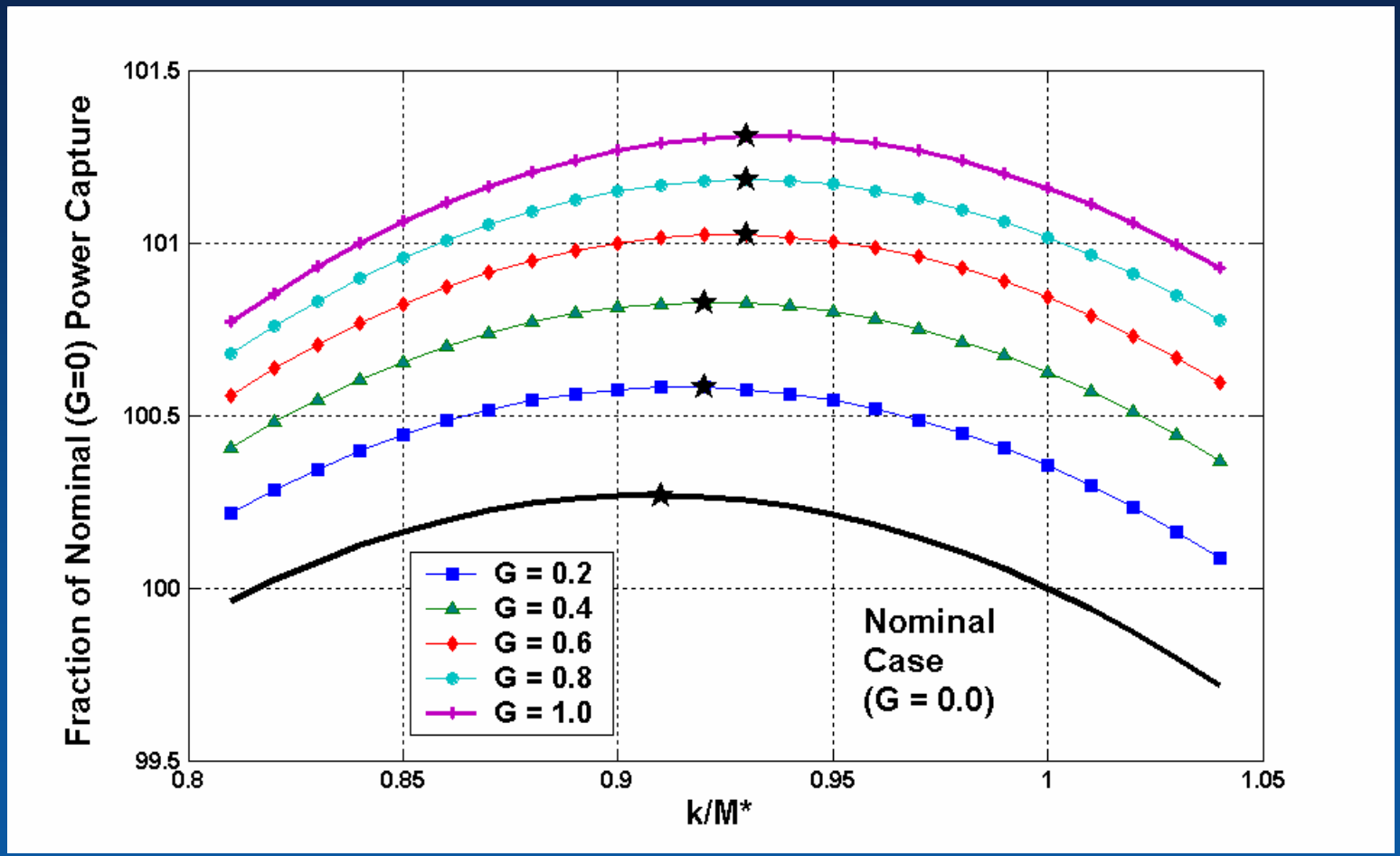


Field test
CART
CART-3
Industry

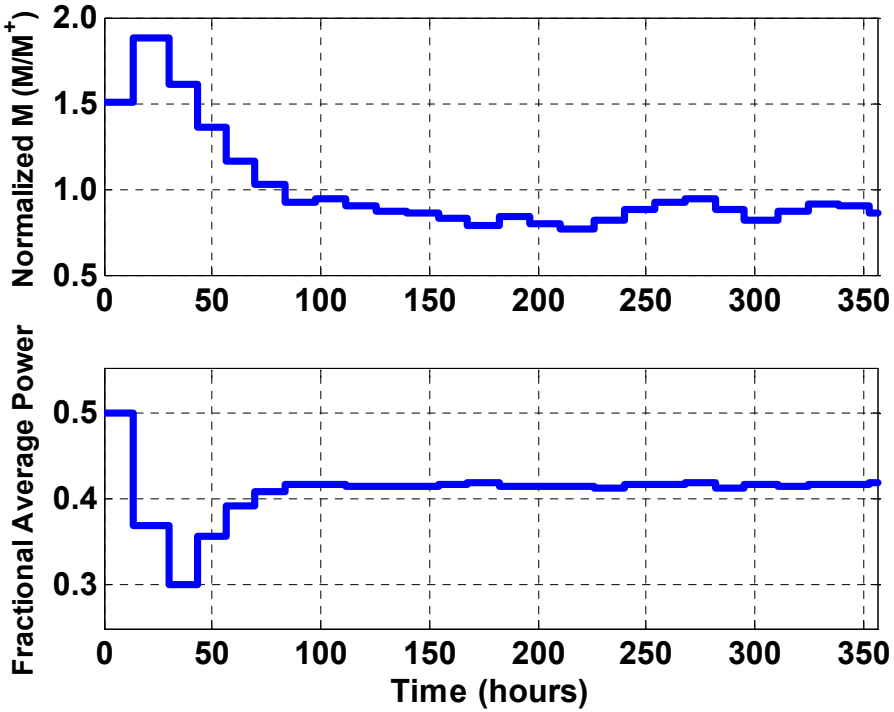
Iterate

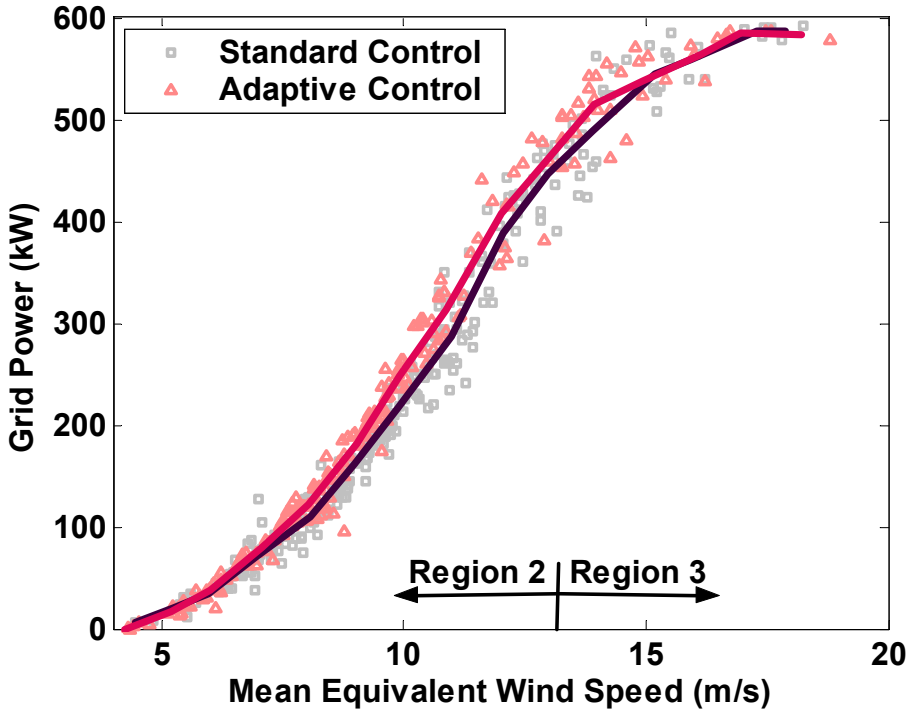
Modify
Analyze data
Make changes

Negative inertia control
0.3% - 1.0% energy capture increase



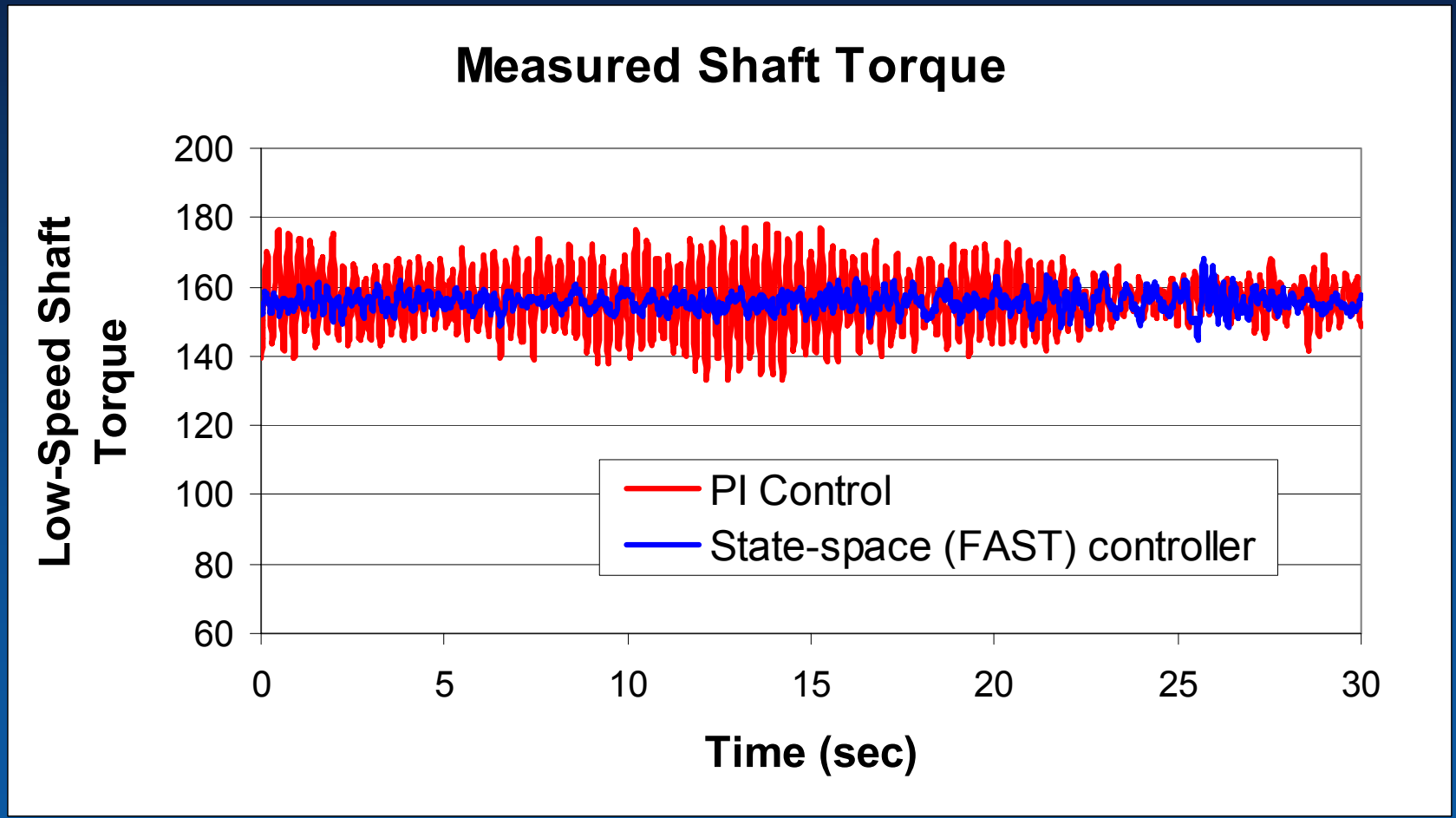
Adaptive control
0.3% - 5% energy capture increase





Feedback control for load reduction

15% - 50% reduction in fatigue loads



What's next?

- Continue code development for better controls integration
- Continue advanced controls development
- More testing with industry partners
- Continue and improve field testing
- Develop new field testing capability

CART-3 – 3-bladed hub testing

- Supplement to the 2-bladed CART
- Advanced controls integration
- Designed for testing modern controls
  - Loads
  - Deflection
  - Advanced sensors

Questions and comments